

## Brief

### Missouri High Performance Concrete Update

*In 1996, Missouri volunteered to participate as a lead state in the AASHTO Lead State Program for High Performance Concrete. The AASHTO Task Force on SHRP Implementation initiated the lead state program in 1996 in an effort to implement specific "high-payoff" SHRP technologies such as high performance concrete. High performance concrete (HPC) technology utilizes innovative design and construction concepts for improved pavements and bridges. As a result, pavements and bridges are constructed having longer service lives with improved performance and greater economic benefits. As a lead state in HPC technology, Missouri is committed to help further the development and implementation of HPC.*

#### Project Description

On November 3, 1998, two companion bridges on Missouri Route 21 in Jefferson County were opened to traffic. The northbound bridge over Route M was constructed using prestressed I-girders made of HPC with design strength of 10,000 psi (release strength 5,500 psi). The southbound bridge over Route M was constructed using prestressed I-girders made of conventional concrete with design strength of 5,000 psi (release strength 4,000 psi). As a result of the increased concrete strength, the HPC bridge required fewer girders than the conventional bridge. The conventional bridge required 24 MoDOT Type 6 girders, while the HPC required only 20 of the MoDOT Type 6 girders.

#### HPC Mix Characteristics

The HPC mix was designed by the fabricator to meet the requirements of the special provisions. The required compressive strength was 10,000 psi at 56 days and the chloride permeability was limited to 1000 coulombs or less in accordance with AASHTO T 277. The HPC specifications were written to minimize allowable tolerances during fabrication for improved quality control. The coarse aggregate had to meet Missouri Standard Specifications, Sec. 1005.1 for pavement quality. The fresh air content could be no less than the design air content, nor could it exceed that value by 3.5 percentage points. The slump could not exceed 8 inches and had to be within 2 inches of that specified in the approved mix design. The w/c ratio had to be within 0.020 of that specified in the approved mix design. Table 1 shows the comparison of the actual HPC mix proportions and the conventional mix proportions.

#### Physical Properties

The compressive strength of the HPC and the conventional mix at various ages are shown in Table 2. In both cases, release strength (HPC 5,500 psi, Conv. 4,000 psi) was reached in 1 day and design strength was reached by 3 days.

The chloride permeability of the HPC was very low, while the chloride permeability of the conventional concrete was moderate. Table 3 shows the specified values for compressive strength and chloride permeability of the two mixes and the actual measured values.

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**Table 1 – Mix Proportions**

	HPC	Conv.
Water (lbs)	219	237
River Type I Cement (lbs)	852	722
W. R. Grace Silica Fume (lbs)	50	N/A
w/c	0.243	
0.328		
Fine Agg. (lbs)		
Mississippi River Sand	905	1193
Coarse Agg. (lbs)		
Plattin Limestone	1977	N/A
Coarse Agg. (lbs)		
Derby Doe Run Dolomite	N/A	1769
Daravair 1400 (oz/sack)	0.5	2.46
Daratarid 17 (oz/sack)	2.83	N/A
Daracem 19 (oz/sack)		

**Table 2**  
**Compressive Strength (psi)**

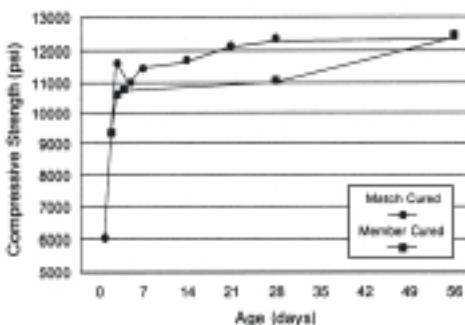
Age	HPC	Conv.
1 day	6,090	5,340
3 days	11,630	5,960
56 days	12,450	6,850
1 year	14,520	<i>Not Tested</i>

Both the HPC and the conventional concrete were subjected to freezing and thawing in accordance with ASTM C666 Procedure B. The freeze-thaw resistance of the conventional concrete was excellent, however the freeze-thaw resistance of the HPC was poor. The poor freeze-thaw performance of the HPC warrants additional investigation. Areas planned for further investigation include: the freeze-thaw durability of the Plattin Limestone; the effect of very impermeable concrete containing silica fume on freeze-thaw performance; and curing procedures that may exaggerate poor freeze-thaw test results. Some researchers feel the continuous wet curing of HPC freeze-thaw specimens amplifies poor test results and have suggested a period of drying time be allowed before the test begins.

## Curing Temperature Research

All of the test specimens for MoDOT's research were cured in a "match-cure" environment in an effort to better simulate the actual member curing temperatures. The temperature of test specimens was maintained within three degrees Fahrenheit of the internal girder temperature. A comparison was made of the compressive strength of these "match-cured" cylinders and member-cured cylinders used by the fabricator. As Figure 1 illustrates, the compressive strength at early ages is higher for "match-cured" cylinders than for member-cured cylinders and should be more representative of the actual girder strength.

Figure 1  
**HPC Compressive Strength**  
Comparison of Member Cured and Match Cured



## Project Costs

Fabrication and placement of the HPC girders per foot of bridge was 16% higher than for the conventional girders. Reduced maintenance and longer life are expected to offset this initial cost.

## Conclusions

The high strength and low permeability has shown that HPC is a viable concept in Missouri, although further study into the freeze-thaw durability is needed.

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**Table 3**

Compressive Strength (psi)		Chloride Permeability (coulombs)	
Specification	Actual	Specification	Actual
HPC 10,000 @ 56 days	12,450	<1000	110
Conv. 5,000 @ 56 days	6,850	N/A	3050

## Nova Chip

### Description:

NovaChip is a paving process that places a thin, coarse aggregate hot mix over a special asphalt membrane. The special NovaBond membrane prevents water leakage and provides a superior bond to the old asphalt or concrete surface. NovaChip combines a surface seal with a hot mix level-paving surface and the flexibility of a thin maintenance treatment, which results in a durable surface. NovaChip can be used as preventative maintenance or as a surface rehabilitation treatment. The NovaChip results in a thinner surface than hot mix making it suitable where overheight clearance and drainage profile problems may occur. It's good for high traffic areas because the process moves quickly and all in one pass. This means the road will be opened sooner resulting in less traffic delays. Currently MoDOT uses hot mix and microsurfaces for its overlays and chip seals for surface restoration and skid resistance. The NovaChip is more durable than a standard chip seal and has no loose chips to contend with. It may also enhance our ability to correct rutting, lengthen asphalt pavement life cycles, and reduce or eliminate wet pavement accidents by providing a minimal hydroplaning surface on the roadways.

### Advantages/Disadvantages:

One of the NovaChip advantages MoDOT is most interested in is the ability of the overlay to dispose of water quickly off the surface thus reducing roadway spray from vehicles and providing greater visibility in wet weather. This is accomplished through its coarse aggregate matrix. Along with a reduction in roadway spray, the skid resistance of NovaChip seems to be good which makes the product desirable at locations where loss of traction due to wet pavement is an issue. Other

advantages of NovaChip are its quick, one-pass, thin lift, and estimated long lasting performance.

One disadvantage is some areas of the initial test section, which is on the north side of St. Joseph placed in October 1998, have developed shelling problems. From a field evaluation in January 1999, it was noticed that a good deal of the loose aggregate laying on the shoulder was coming from snow plow damage to the inside lane edge of the NovaChip pavement. This was apparently occurring when the inside shoulder was being cleared of snow. There was also damage showing up in the middle of the lanes, some of which could be attributed to snow plow gouge. However, some irregular looking areas were noted at the time of placement of this initial test section. These irregular looking areas may have been the cause of the pavement to be more susceptible to holding moisture, bringing about accelerated effects from freeze/thaw cycles or possibly allowing snow plows to penetrate down into the surface thus triggering shelling to occur.

A second test section was placed on the south side of St. Joseph in July 1999. It is hopeful this second test section will provide a more durable result. It is in the process of going through its first winter season in 1999 – 2000.

### Cost:

- For a 1-inch hot mix overlay, the estimated life is 4 to 10 years. Assuming an average life to be 7 years at a cost of approximately \$1.36/sq. yd, this equates to an approximate annual cost of \$2,570 per two-11ft. lane miles.
- A Ralumac surface is expected to have an equivalent life and cost figures of a hot mix overlay.

- For Chip seals, the estimated life is 4 to 10 years. Assuming an average life to be 7 years at a contract cost of \$0.75/sq. yd, this equates to an approximate annual cost of \$1,400 per two-11ft. lane miles.
- For a standard 3/8" to 3/4" NovaChip hot mix surface, the estimated life is most likely comparable to a hot mix overlay of 4 to 10 years. Assuming an average life to be about 7 years at a cost of approximately \$3.00/sq. yd, this equates to an annual cost of \$5,500 per two-11 ft. lane miles.

### Conclusions:

One conclusion that can be drawn at this time is that NovaChip has proven itself to be a wearing surface which sheds away water from the surface to reduce hydroplaning and reduces road spray from vehicles thus providing greater visibility for drivers. The reduction of hydroplaning should allow more of the vehicle tire to be in contact with the road. This is evident in the decreased amount of reports of out of control accidents at these test sites. Another conclusion, which can be drawn at this time, is the drastic cost difference between the NovaChip surface and the 1-inch hot mix or the chip seal treatments. Using the costs from the test section, NovaChip is approximately twice the price of hot mix.

Further monitoring during this evaluation will determine the durability of NovaChip and conclude if NovaChip will or will not be another pavement surface solution tool. Upon completion of this evaluation, a final report will be distributed with the appropriate recommendations.

### Contacts:

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*Or*  
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(573) 751-4620

# National Highway Institute (NHI) course presented

A three-day NHI Course “**Culvert Design**” was presented to MoDOT personnel in December & January. The sixty-plus participants included representatives from Design, Bridge, Districts and FHWA

This course provided participants with the recommended design procedures for the hydraulic design of culverts. Computer programs were distributed, discussed and demonstrated. A portable hydraulic flume was set up in the classroom for the participants to observe numerous hydraulic principles and the hydraulic effects of improved inlets, pipe slope, material roughness and various end treatments. The participants took velocity and discharge measurements from the flume while in various setups and used the information to make actual design calculations. The training course covered the following topics:

- \* “*Hydraulic Design of Highway Culverts*” (FHWA publication HDS-5)
- \* *Culvert Hydraulic Design/Analysis Computer Program (HY-8)*
- \* “*Hydraulic Design of Energy Dissipators for Culverts and Channels*” (FHWA pub. HEC-14)

Objectives: Upon completion of the course, participants will be able to:



The portable hydraulic flume demonstrates the effects of various hydraulic principles.

1. Identify design alternatives based on culvert type, material, shape and service life considerations.
2. Describe the factors that govern inlet and outlet control and predict how each factor influences culvert performance.
3. Calculate tailwater depth and velocity and describe how tailwater effects culvert performance.
4. Design conventional culverts using HDS-5.
5. Improve culvert performance for inlet control culverts by designing and improved inlet using HES-5.
6. Evaluate culvert outlet velocity and the need for energy dissipators, and select alternative energy dissipators using HEC-14.
7. Identify appropriate computer programs for culvert and energy dissipator design.

The target audience was engineers and technicians responsible for culvert design on transportation facilities. The course is suitable for entry level personnel and is valuable as a refresher course for those with previous culvert design training or experience.



NHI course participants work on various hypothetical culvert design projects.

# Federal Highway Administration (FHWA) requires certification

The FHWA has issued guidelines to states to ensure that personnel who perform acceptance testing for highway projects are certified. The certification process consists of classroom instruction, performance demonstrations, and testing. There will be approximately 800 Missouri Department of Transportation (MoDOT) employees throughout the state attend training classes that consist of two levels of training.

**Level I:** Consists of introductory topics in concrete, aggregate, and bituminous testing and sampling.

**Level II:** Consists of two possible modules in the areas of Soils/Aggregates and Concrete. These modules cover advance topics for testing.

Certifications are valid for 3 years when a re-certification will be required. Certifying non-MoDOT inspection forces will occur when the acceptance process is Quality Control/Quality Assurance (QC/QA). This is currently required for Superpave projects with the training provided by UMR as a short course.

Training in Level 1 is complete and Level 2 will be completed by April 1. Upon completion of certification, MoDOT employees will have completed the same requirement as other states, such as Iowa, Illinois, Kansas and Arkansas. This training and certification provides verification that materials used in highway construction meets federal and state guidelines.

You can contact Bruce Loesch, MoDOT Materials Qualifications Engineer, with questions concerning this program. 573-522-2742 or [loescr@mail.modot.state.mo.us](mailto:loescr@mail.modot.state.mo.us)

# Safety Inspection of In-Service Bridges

**NHI Course 13055 Available in Fall 2000.**

A two-week In-Service Bridge Inspection Course is anticipated in cooperation with Kansas Local Technical Assistance Program and Kansas Department of Transportation.

This course is based on the updated "Bridge Inspector's Training Manual 90," providing training on the safety inspection of a variety of in-service highway bridges. Satisfactory completion of this course will fulfill the training requirements of the National Bridge Inspection Standards (NBIS) for a comprehensive training course, based on the manual.

A comprehensive examination based on the content of the course has been developed and will be administered to the participants on the last day of the course. The host State may monitor the examination and retain the scores for purposes of qualifying or certifying bridge inspectors under the State's procedures.

The training course will cover the following topics:

- Bridge Inspection Programs
- Review of Basic Concepts
- Safety
- Inspection Documentation
- Inspection and evaluation of:
  - Bridge Decks
  - Common Timber, Steel and Concrete Superstructures
  - Fracture Critical Bridge Members
  - Bridge Bearings
  - Substructures
  - Waterways
  - Underwater Inspections
  - Culverts

Questions concerning registration interest may be directed to the Missouri Local Technical Assistance Program at (573) 526-5381 or by completing a registration form.

## Registration Form

This form is for use by local agency personnel scheduling Training.

Course \_\_\_\_\_

Date(s) \_\_\_\_\_

Contact Person \_\_\_\_\_

Title \_\_\_\_\_ Phone No. \_\_\_\_\_

Name of Agency \_\_\_\_\_

Address \_\_\_\_\_  
(Street/P.O. Box) (City) (State) (ZipCode)

### EMPLOYEE(s) YOU WISH TO REGISTER

Name \_\_\_\_\_ Title \_\_\_\_\_

Name \_\_\_\_\_ Title \_\_\_\_\_

Name \_\_\_\_\_ Title \_\_\_\_\_

Each registrant scheduled to attend this course will be sent a confirmation notice and registration based on space available/session.

Please mail to: Research, Development and Technology  
MoDOT, Training Registration  
P.O. Box 270, Jefferson City, MO 65102  
Fax (573) 526-4337

# Pedestrians, bicyclists benefit from new MoDOT guidelines

JEFFERSON CITY - The needs of Missouri's bicyclists and pedestrians will be considered in future highway projects through new efforts launched by the Missouri Department of Transportation.

"We've developed a guide that encourages bicycle and pedestrian facilities when it's appropriate and feasible. We'll look at bicycle and pedestrian accommodations during preliminary studies for highway projects, as well as during design and construction," MoDOT Director Henry Hungerbeeler said.

The guide reflects the department's desire to serve Missouri's total transportation needs, Hungerbeeler said. MoDOT will consider bicycle and pedestrian options in a variety of situations. These include when a community has a bicycle pedestrian plan or requests consideration of bicycle and pedestrian options, when bicycle and pedestrian traffic generators such as schools or shopping areas are near MoDOT projects and when a route crosses barriers such as rivers, major highways or railroads.

Hungerbeeler said items MoDOT will consider include sidewalks, bicycle and pedestrian paths, mid-block pedestrian crossings, designated bicycle lanes and shared lanes, which are wider than the standard 12-foot width to accommodate both a bicyclist and a motorist.

"We'll also look at appropriate signs indicating the presence of bicyclists and pedestrians. On highways where bicyclists are expected, we'll ensure that highway grates either conform to bicycle use or are retrofitted. We'll also review use and design of rumble strips on paved shoulders that bicyclists might use so bicyclists don't have to run over them," Hungerbeeler said. Rumble strips are

grooves cut in paved shoulders that make noise when driven over to alert motorists they're off the roadway.

"We'll also review signalized intersections and how pedestrians cross at them," Hungerbeeler said.

He noted, however, that bicycle and pedestrian accommodations are not options on all highways. "For instance, bicycle lanes generally aren't permitted on interstate highways for safety and speed reasons, nor would wider or shared lanes be considered on interstate highways. We would, however, consider a bicycle lane on the shoulder of interstate highways at major river crossings, if it's practical."

Hungerbeeler said the bicycle and pedestrian guide will help communities in

planning and implementing bicycle and pedestrian programs. "We've also established the Missouri Bicycle and Pedestrian Advisory Committee (MoBPAC) to help improve conditions for walking and bicycling on the state and local road systems. The committee includes representatives from state and local governments, bicycling groups and health and fitness and planning agencies."

More information about MoDOT's bicycle and pedestrian guidelines and the MBPAC is available by calling MoDOT customer service at 1-888-ASK MODOT (888-275-6636), on the department's internet webpage at [www.modot.state.mo.us](http://www.modot.state.mo.us) or by contacting Bicycle and Pedestrian Program Coordinator Dennis Scott at 573-526-2816.

## Federal Wage Rates

Beginning January 14, 2000, "Required Federal Aid Provisions" and "Federal Wage Rate" information will be available free of charge on the Missouri Department of Transportation web site at [www.modot.state.mo.us](http://www.modot.state.mo.us) under "Business with Modot", "Bid Opening Information", "Notices of Bid Openings, Addendums, EBS Files", then select Current Federal Wage Rates. Applicable wage rate information will be provided for each bid opening. The Federal Wage Rates in effect ten (10) days prior to the bid opening date will be the Federal Wage Rates included in the final contract documents and should be the wage rates used when preparing your bid.

Printed copies of "Required Federal Aid Provisions" and "Federal Wage Rates" will be available on a subscription basis at a cost of \$15.00 per year. Copies of the Federal Wage Rate will continue to be provided free of charge until your current Bid Opening Publication subscription expires. At that time you will be provided an opportunity to subscribe to the Federal Wage Rate documents at a subscription rate of \$15.00 per year. If you elect not to subscribe, no further printed copies of the Federal Wage Rate documents will be provided.

Beginning with the February 18, 2000 bid opening, only one copy of the "Required Federal Aid Provisions" and "Federal Wage Rates" per bid opening will be mailed to prime contractors ordering plans. The "Required Federal Aid Provisions" and "Federal Wage Rate" will be provided by regular mail ten (10) days prior to the bid opening date. As stated above, once your current Bid Opening Publication subscription expires, you will no longer receive the "Required Federal Aid Provisions" and Federal Wage Rates" in the mail unless you are on the subscription list for these documents. This change will eliminate duplicate copies of the Federal Wage Rate information being provided to contractors when ordering multiple bidding documents and ensures contractors receive only the Federal Wage Rate information that will be included in the final contract documents.

If you have any questions on these changes, please contact Carolyn Brockes at (573) 526-2907.

# Red Light Running (RLR) Automated Enforcement Program

The incidence of motorists violating the red phase of a traffic signal has been on the rise and is a contributing factor to intersection crashes. Technology has become available that automatically detects a motorist running the red light and records photographically the occurrence, which in turn is used for violation citations.

The high percentage of crashes that occur at intersections has contributed to identifying red light running equipment as a countermeasure to be considered when addressing intersection crashes. This equipment is a form of automated enforcement, which involves the use of image capture technology. It can detect and cite motorist who enter a signalized intersection in violation of the red phase and has the potential to reduce fatalities, injuries and crashes by enhancing respect for traffic control devices such as traffic signals.

## How to address RLR?

There are a number of countermeasures available to address the RLR problem. These measures include:

- Removal of unwarranted traffic signals- remove signals from low traffic volume locations.
- Signal Timing-provide adequate clearance or change intervals.
- Enforcement- use new technologies to aid in enforcement, given that current resources to enforce traffic laws are inadequate in relation to the number of vehicles on the road.

FHWA funded the demonstrations and evaluations of the RLR automated technology at five municipalities. The results from these demos plus RLR programs implemented at two cities are synthesized in Publication No. FHWA-IF-00-004.

## This synthesis and evaluation includes:

Literature Review-Scope of the RLR problem  
Electronic Enforcement Technology  
RLR City Projects  
Electronic Enforcement Implementation

## Summary and Conclusions

### *The major conclusions*

#### **Reduction in Red Light Violations**

Implementation of an automated enforcement program for red light running should translate into at least 20 and as much as a 60 percent reduction in violations.

#### **Reduction in Crashes**

There was a reduction in crashes in Howard County and Polk County when comparing crash data one year before and one year after the RLR campaigns were implemented. However, these simple comparisons are not statistically rigorous to conclude that the RLR program will result in crash reduction immediately or in the long run.

Additional crash data are needed to validate and quantify the RLR automated enforcement programs implication on crashes.

#### **Cost Savings over Manual Enforcement**

Howard County estimated that automated enforcement of one intersection could produce 2,000 citations in one month. For two police officers it would take about two years to issue 2,000 citations.

Manual enforcement of red light violators can be dangerous to police, motorists, pedestrians and bicyclists.

#### **Public Acceptance**

Before a jurisdiction implements a RLR automated enforcement program, it should make sure that there is a need (high accident/violation rates related to RLR) for the program. Video of intersections with high violation rates is a useful way to convince the public of the need.

The public will accept this type of program if statistics of lives saved, number of accidents saved, or money saved are available.

Public acceptance may impact the success of a RLR automated enforcement program. San Francisco, Howard County, Polk County and Los Angeles County informed the public early in the program, which translated to quicker acceptance.

## Institutional Barriers

Legal and Social institutional barriers significantly affect RLR automated enforcement programs.

Initially some groups felt RLR programs infringed on motorist's rights, however, Supreme Court decisions have led to the belief that the use of automated enforcement technology does not violate an individual's right to privacy.

Legislation should be established that allows for the use of automated enforcement technology. Registered owner liability is the preferred legislation.

Public awareness campaigns that provide detailed information should accompany RLR automated enforcement programs.

The technology for these programs are constantly changing and research should be performed to identify the appropriate system and vendor for the needs of the potential user.

## Cape Girardeau Conducts Research on RLR

Sgt. J.R. Davis, Traffic Division Director for the City of Cape Girardeau, has been conducting research on automated red light enforcement for approximately 1-½ years. Sgt. Davis has been in contact with highway safety advocates and technology vendors.

As a result of Sgt. Davis' research, he has initiated the process to propose a local enabling ordinance allowing the City of Cape Girardeau to utilize RLR enforcement.

A first step of the process was to introduce the idea to the community and interested parties. On February 23, 2000 a RLR presentation in Cape Girardeau had nineteen participants from:

Springfield, MO - Police Department  
Independence, MO - Police Department  
Columbia, MO - Police Department  
Cape Girardeau, MO- Police Department

Missouri Division Highway Safety  
Missouri Department of Transportation  
Missouri State Highway Patrol

Missouri Department of Transportation  
Technology Transfer Assistance Program  
Local Technical Assistance Program  
P.O. Box 270  
Jefferson City, MO 65102

Telephone  
573-751-0852

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